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Request for grant of a patent

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Application number GB

0721995.9

1. Your reference: *(optional)* 102085.GB.01/NHE

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Patents ADP number *(if you know it)*:

08333072003

If the applicant is a corporate body, give the country/state of its incorporation: United Kingdom

3. Title of the invention: An Improved Mist Generating Apparatus

4. Name of your agent *(if you have one)*: Murgitroyd & Company

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Are all the applicants named above also inventors? YES ☐ NO ☑

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Description: 14

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12. Name, e-mail address, telephone, fax and/or mobile number, if any, of a contact point for the applicant:

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AN IMPROVED MIST GENERATING APPARATUS

The present invention is directed to the field of mist generating apparatus, which generate and spray a mist of droplets. The apparatus of the present invention is particularly, although not exclusively, suited for use in cooling, fire suppression and decontamination applications.

Mist generating apparatus are known which inject a high-velocity transport fluid into a working fluid in order to atomise the working fluid and form a dispersed droplet-vapour flow regime which is then sprayed into the atmosphere. Examples of such apparatus can be seen in WO2005/082545 and WO2005/082546 to the same applicant. In the apparatus disclosed in these publications, a transport fluid is injected at high velocity into the working fluid and the working fluid is sprayed from a nozzle in a single general direction. When only sprayed in a single direction, the spray pattern of the droplets will have limited coverage. As a result, when used in an application to suppress a fire in a room, for example, a number of mist generating apparatus of this type will be needed to ensure coverage of the entire room.

It is an aim of the present invention to obviate or mitigate the aforementioned disadvantage.

According to a first aspect of the present invention, there is provided a mist generating apparatus, comprising:

a first working fluid passage in fluid communication with a first working fluid inlet and a first working fluid outlet;

a transport fluid passage in fluid communication with a supply of transport fluid; and

a transport fluid nozzle in fluid communication with the transport fluid passage, the nozzle having a nozzle inlet, a nozzle outlet, and a throat portion intermediate the nozzle inlet and nozzle outlet, the throat portion having a smaller cross-sectional area than the nozzle inlet and outlet;

wherein the first working fluid outlet is located adjacent the nozzle outlet such that a mist is formed as a stream of working fluid issuing from the working fluid outlet is atomised by a stream of transport fluid issuing from the nozzle outlet;

and wherein the first working fluid outlet and the nozzle outlet each extend around at least a portion of the perimeter of the apparatus such that the mist is sprayed over an angle of substantially 90 degrees or more.

Preferably, the first working fluid outlet and the nozzle outlet each extend around the entire perimeter of the apparatus such that the mist is sprayed over an angle of substantially 360 degrees.

Preferably, the first working fluid outlet and the nozzle outlet each extend continuously around at least a portion of the perimeter of the apparatus.

Alternatively, the first working fluid outlet and the nozzle outlet each extend discontinuously around at least a portion of the perimeter of the apparatus such that the apparatus comprises a plurality of first working fluid outlets and nozzle outlets.

Preferably, the apparatus further comprises a first member having a longitudinally extending bore therethrough, and a first flange projecting radially outwardly from a first end thereof, wherein the first working fluid inlet and first working fluid passage are located in the first member, and

the first working fluid outlet is located on a first outer surface of the first flange.

Preferably, the apparatus further comprises a second member having a longitudinally extending shaft and a second flange projecting radially outwardly from an end of the shaft, wherein the shaft is located in the bore of the first member such that the transport fluid passage is defined between the shaft and the wall of the bore, and the transport fluid nozzle is defined between a second outer surface of the second flange and the first outer surface of the first flange.

Preferably, the apparatus further comprises a second working fluid passage in fluid communication with a second working fluid inlet and a second working fluid outlet, wherein the first and second working fluid outlets are located adjacent the nozzle outlet such that a mist is formed as streams of working fluid issuing from the working fluid outlets are atomised by a stream of transport fluid issuing from the nozzle outlet, and wherein the second working fluid outlet extends around at least a portion of the perimeter of the apparatus such that the mist is sprayed over an angle of substantially 90 degrees or more.

Preferably, the second working fluid outlet extends around the entire perimeter of the apparatus such that the mist is sprayed over an angle of substantially 360 degrees.

Preferably, the second working fluid outlet extends continuously around at least a portion of the perimeter of the apparatus.

Alternatively, the second working fluid outlet extends discontinuously around at least a portion of the perimeter of the apparatus such that the apparatus comprises a plurality of second working fluid outlets.

Preferably, the second working fluid inlet and the second working fluid passage are located in the second member, and the second working fluid outlet is located on the second outer surface of the second flange.

Preferably, the first and second working fluid passages extend radially outwardly within the first and second flanges. Preferably, the first working fluid outlet extends around the first member. Preferably, the second working fluid outlet extends around the second member.

Preferably, the second member is adjustable relative to the first member, such that the distance between the first and second outer surfaces of the first and second flanges can be varied. Thus, the cross-sectional area of the transport fluid nozzle and the area ratio between the nozzle throat and nozzle outlet can be varied.

In one preferred embodiment, both the first and second flanges include an inner working fluid outlet and an outer working fluid outlet located radially outwardly of the inner working fluid outlet.

In an alternative preferred embodiment, the first flange includes an inner working fluid outlet and an outer working fluid outlet located radially outwardly of the inner working fluid outlet.

Preferably, both inner and outer outlets extend around at least a portion of the perimeter of the first flange.

Preferably, the inner and outer working fluid outlets each extend around the entire perimeter of the first flange.

Preferably, the inner and outer working fluid outlets each extend continuously around at least a portion of the perimeter of the first flange.

Alternatively, the inner and outer working fluid outlets each extend discontinuously around at least a portion of the perimeter of the first flange such that the apparatus comprises a plurality of inner and outer working fluid outlets.

Preferably, one or both of the first and second outer surfaces of the first and second flanges includes protrusions and/or indentations to enhance flow turbulence between the first and second outer surfaces.

Preferably, one or more of the working fluid outlets is provided with a working fluid nozzle, wherein the angle of the working fluid nozzle can be adjusted relative to the first and second outer surfaces. Thus, the angle at which the working fluid streams encounter the transport fluid can be varied.

Where the working fluid outlet and nozzle outlet extend continuously around the perimeter of the apparatus, the apparatus preferably further comprises blocking means which may be located between the first and second outer surfaces to selectively block a portion of the working fluid outlets and the transport fluid nozzle outlet. In doing so, the blocking means can adapt the apparatus such that it sprays the mist over only a portion of the area covered by the apparatus.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a vertical section through a first embodiment of a mist generating apparatus;

Figure 2 shows a vertical section through a second embodiment of a mist generating apparatus; and

Figure 3 shows a vertical section through a third embodiment of a mist generating apparatus.

Figure 1 shows a first embodiment of a mist generating apparatus, generally designated 100. The apparatus is adapted to produce a substantially annular mist or spray pattern of atomised droplets over an angle of substantially 360 degrees, and comprises a first member 101 and a second member 102.

The first member 101 has a generally cylindrical body 114 which has a first end connected to a supply of working fluid (not shown) and a second end having a first flange, or disc, 112 projecting radially outwardly therefrom. The body 114 defines a first working fluid inlet 130 which is in fluid communication with the working fluid supply. The body 114 also includes a central bore 118, which extends through the body 114 in a direction generally parallel with the first working fluid inlet 130. The first disc 112 defines a first working fluid passage 132 which is generally perpendicular to, and in fluid communication with, the first working fluid inlet 130. A first working fluid outlet 160 is provided at the remote end of the first working fluid passage 132 so that working fluid may pass from the first working fluid passage 132 through the outer surface 140 of the first disc 112. The first working fluid outlet 160 has a reduced cross-sectional area compared to the first working fluid passage 132. In the illustrated

embodiment, both the first working fluid passage 132 and first working fluid outlet 160 extend about the entire perimeter of the first disc 112, such that both the passage 132 and outlet 160 form annuli about the first member 101.

The second member 102 has a longitudinally extending shaft 124 having a first end connected to a supply of working fluid (not shown) and a second end having a second flange, or disc 122, projecting radially outwardly therefrom. During assembly, the shaft 124 is received in the bore 118 such that the wall 119 of the bore 118 and shaft 124 define a transport fluid passage 128 between them.

The shaft 124 has a second working fluid inlet 134 which is connected to a working fluid supply. The second working fluid inlet 134 is generally parallel to the first working fluid inlet 130 and the transport fluid passage 128. The second disc 122 defines a second working fluid passage 136 which is generally perpendicular to, and in fluid communication with, the second working fluid inlet 134. A second working fluid outlet 170 is provided at the remote end of the second working fluid passage 136 so that working fluid may pass from the second working fluid passage 136 through the outer surface 142 of the second disc 122. The second working fluid outlet 170 has a reduced cross-sectional area compared to the second working fluid passage 136. The second working fluid outlet 170 is oriented such that working fluid will pass out of the outlet in the general direction of the first disc 112 and first working fluid outlet 160. In the illustrated embodiment, both the second working fluid passage 136 and second working fluid outlet 170 extend about the entire perimeter of the second disc 122, such that the outlet 170 forms an annulus about the second member 102.

With the shaft 124 inserted into the bore 118 of the first member 101, the first and second discs 112,122 are brought into close proximity. With the first and second discs 112,122 close to one another, their respective outer surfaces 140,142 define a nozzle 150 having a convergent-divergent inner geometry. By convergent-divergent geometry, it is meant that the nozzle 150 has a nozzle inlet 151 and a nozzle outlet 155, and a throat portion 153 intermediate the nozzle inlet 151 and nozzle outlet 155 which has a reduced cross-sectional area when compared with that of the inlet 151 and outlet 155. The nozzle 150 is in fluid communication with the transport fluid passage 128 to receive transport fluid therefrom. As with the first and second working fluid passages 132,136 and the transport fluid passage 128, the nozzle 150 outlet extends around the entire perimeter of the apparatus 100. Consequently, the nozzle outlet forms an annulus.

It is preferable that the position of the second member 102 can be adjusted relative to the first member 101, and that this is achieved by varying the extent to which the shaft 124 is axially inserted into the bore 118. This adjustment varies the distance between the outer surfaces 140,142 of the discs 112,122, and consequently the internal geometry of the nozzle 150 can be adjusted to vary the atomisation of the working fluid by the transport fluid.

The method of operation of the apparatus shown in Figure 1 will now be described. Initially, a working fluid - preferably water - is supplied from a working fluid supply to the first and second working fluid inlets 130,134. The respective inlets 130,134 may receive working fluid from the same supply, or else separate supplies can be used for each inlet 130,134. The working fluid will pass from the inlets 130,134 into the first and second working fluid passages 132,136, and from there to the respective working fluid outlets 160,170. As the outlets 160,170 are preferably of a reduced

cross-sectional area compared to their respective working fluid passages 160,170, there is a build up of pressure in the working fluid passages 132,136. This leads to a stream of working fluid spraying out through the outlets 160,170.

A transport fluid – preferably steam - is supplied to the transport fluid passage 128 from a transport fluid supply, and will then pass through the transport fluid nozzle 150. As the transport fluid passes through the convergent-divergent geometry created by the nozzle inlet 151, throat portion 153 and nozzle outlet 155, it undergoes an acceleration which causes the transport fluid to leave the nozzle outlet 155 at very high - and in some instances supersonic – velocity.

As the high velocity transport fluid leaves the nozzle outlet 155, it comes into contact with the streams of working fluid exiting the working fluid outlets 160,170 adjacent the nozzle outlet 155. As the two fluids come into contact an energy transfer takes place between the two, primarily as a result of mass and momentum transfer between the high velocity transport fluid and the relatively low velocity working fluid. In the case where steam is the transport fluid, heat transfer between the high temperature transport fluid and lower temperature working fluid also forms part of the energy transfer between the two fluids. This energy transfer imparts a shearing force on the working fluid streams, leading to the atomisation of the working fluid streams. This atomisation leads to the creation of a dispersed droplet-vapour flow regime exiting the apparatus 100 over a 360 degree angle as a mist. By varying the relative positions of the first and second members 101,102, and consequently the distance between the surfaces 140,142, the velocity of the transport fluid can be varied such that the degree of atomisation of the working fluid can also be varied accordingly.

The atomisation of the working fluid is achieved using primary and secondary break-up mechanisms. The primary mechanism is the high shear force applied to the working fluid by the transport fluid, which forms ligaments at the boundary surface of the water. These ligaments are stripped from the surface and atomised into droplets. Two secondary break-up mechanisms further atomise the working fluid droplets produced by the primary break-up. These secondary mechanisms are a further shear force caused by the remaining differential between the relative velocities of the transport and working fluid streams, and the turbulent eddy break-up of the working fluid caused by the turbulent flow of the transport fluid.

As the working fluid and transport fluid passages 132,136,128, the working fluid outlets160,170, and the nozzle 150 extend about the entire perimeter of the apparatus 100, the mist sprayed from the apparatus exits the apparatus in an annular, 360 degree, stream. Thus, the apparatus 100 sprays the mist over an angle of substantially 360 degrees, allowing improved coverage of an area when compared to existing mist generating apparatus which only spray in a single general direction.

The working fluid outlets 160,170 of the first embodiment of the present invention are shown in Figure 1 to both be angled to direct their respective streams of working fluid downstream and away from the nozzle outlet 155. In this manner, the streams will collide and disrupt one another. This disruption of the working fluid streams augments and further improves the atomisation of the working fluid caused by the transport fluid exiting the nozzle outlet 155.

Alternative arrangements of the working fluid outlets can also be incorporated into the present invention to further improve atomisation performance. A second preferred embodiment of the apparatus is shown in Figure 2, and is generally designated 100'. The second embodiment includes one such alternative arrangement in which the first and second working fluid passages 132',136' each have a respective inner working fluid outlet 160a,170a and outer working fluid outlet 160b,170b. The inner and outer outlets form concentric annuli about the first and second discs 112,122. As with the first embodiment, the pair of inner outlets 160a,170a and the pair of outer outlets 160b,170b are angled to direct their respective streams of working fluid downstream and away from the nozzle outlet 155'. In this manner, the streams from the inner outlets 160a,170a will collide and disrupt one another, as will the streams from the outer outlets 160b,170b. The arrangement of the second embodiment further improves the disruption of the working fluid streams that augments and further improves the atomisation of the working fluid by the transport fluid.

In Figure 3, a third embodiment of the apparatus, generally designated 100", is shown which employs a further alternative arrangement of working fluid outlets. This third embodiment is effectively a combination of components from the first and second embodiments, combining a first member 101" of the type used in the second embodiment with a second member 102" of the type used in the first embodiment. As a result, the first working fluid passage 132" has inner and outer working fluid outlets 160a,160b as with the second embodiment, but the second working fluid passage 136" located in the second member 102" has only a single working fluid outlet 170 as with the first embodiment. The working fluid outlets 160a,160b of the first member 101" and the working fluid outlet 170 of the second member 102" are positioned on their respective members such that they are staggered, or offset. In other words, the

working fluid outlet 170 is positioned such that its annulus lies between those of the inner and outer working fluid outlets 160a,160b relative to the transport fluid nozzle 150". In this third embodiment, the working fluid streams issuing from the outlets 160a,160b,170 do not directly collide with one another, but instead create a degree of turbulence which disrupts each working fluid stream to further enhance the atomisation of the working fluid achieved by the transport fluid.

The outer surfaces 140,142 of the discs 112,122, which define the transport fluid nozzle 150, can include protrusions or indentations to further enhance the turbulence as the transport fluid atomises the working fluid. Such a modification could be made to any of the three embodiments described above.

Whilst the illustrated embodiments of the present invention all employ a second working fluid passage and second working fluid outlet(s) in the second member, it should be understood that the apparatus may also operate successfully with only the first working fluid passage and outlets in the first member. In such an instance, the second outer surface of the second disc would still assist in defining the transport fluid nozzle, but no working fluid would be sprayed from the second disc. However, for optimum atomisation of the working fluid, it is preferable for there to be first and second working fluid passage and outlets in the respective first and second discs.

The nozzle outlets, the first working fluid outlet of the first embodiment and the inner and outer outlets of the second and third embodiments are described in the embodiments above as being annular and extending about the entire perimeter of the apparatus. However, it should be appreciated that one or more of the nozzle outlets, the first working fluid

outlets and the inner and outer outlets may instead extend around only a portion of the apparatus such that a mist is sprayed over an angle of substantially 90 degrees or more. The same may apply to the second working fluid outlet.

Furthermore, one or more of the nozzle outlets, the first and second working fluid outlets and inner and outer outlets may extend discontinuously around the perimeter of the apparatus, either over a portion of the perimeter or the entire perimeter. Consequently, the apparatus may comprise a plurality of one or more of the nozzle outlets, first and second working fluid outlets and inner and outer outlets.

The plurality of first working fluid outlets are each in fluid communication with a single first working fluid passage. Alternatively, the first disc can include a corresponding plurality of first working fluid passages, each of which is in fluid communication with a respective one of the plurality of first working fluid outlets.

The plurality of second working fluid outlets are each in fluid communication with a single second working fluid passage. Alternatively, the second disc can include a corresponding plurality of second working fluid passages, each of which is in fluid communication with a respective one of the plurality of second working fluid outlets.

Furthermore, the angle of each working fluid outlet and inner and outer outlet and its configuration (e.g. area ratio and associated included angle) can be adapted to provide a mist with desired properties. These adjustments are preferably made during manufacture of the apparatus. However, the working fluid outlets can be provided with directional working

fluid nozzles which can be adjusted to vary the angle at which the working fluid stream encounters the transport fluid.

Whilst the transport fluid nozzle preferably produces a substantially annular mist, it may be desirable to block selective portions of the nozzle by way of a blocking means. For example, if locating a mist generating apparatus of the present invention in the corner of a room, a blocking portion may be inserted between the first and second outer surfaces to block the working fluid outlets and the transport fluid nozzle outlet. This ensures that all of the mist is sprayed out into the room and none of the mist is wasted by being sprayed directly into the corner.

Whilst the inlets, passages, outlets and nozzles of the preferred embodiments have been described as handling working fluid or transport fluid, it should be appreciated that the apparatus can be reconfigured to reverse the layout described herein. In other words, the working fluid inlets, passages and outlets could be used to handle transport fluid, whilst the transport fluid inlets, passages and nozzle could be used to handle working fluid. In such a case, what are currently the working fluid passages would need to be modified to provide a convergent-divergent internal geometry so as to accelerate the transport fluid to the appropriate velocity to atomise the working fluid.

In the preferred embodiment described herein, the transport fluid used is steam. However, it should be understood that other fluids may be used instead. For example, a compressed gas such as air or nitrogen could be used in place of steam.

These and other modifications and improvements can be made without departing from the scope of the present invention.

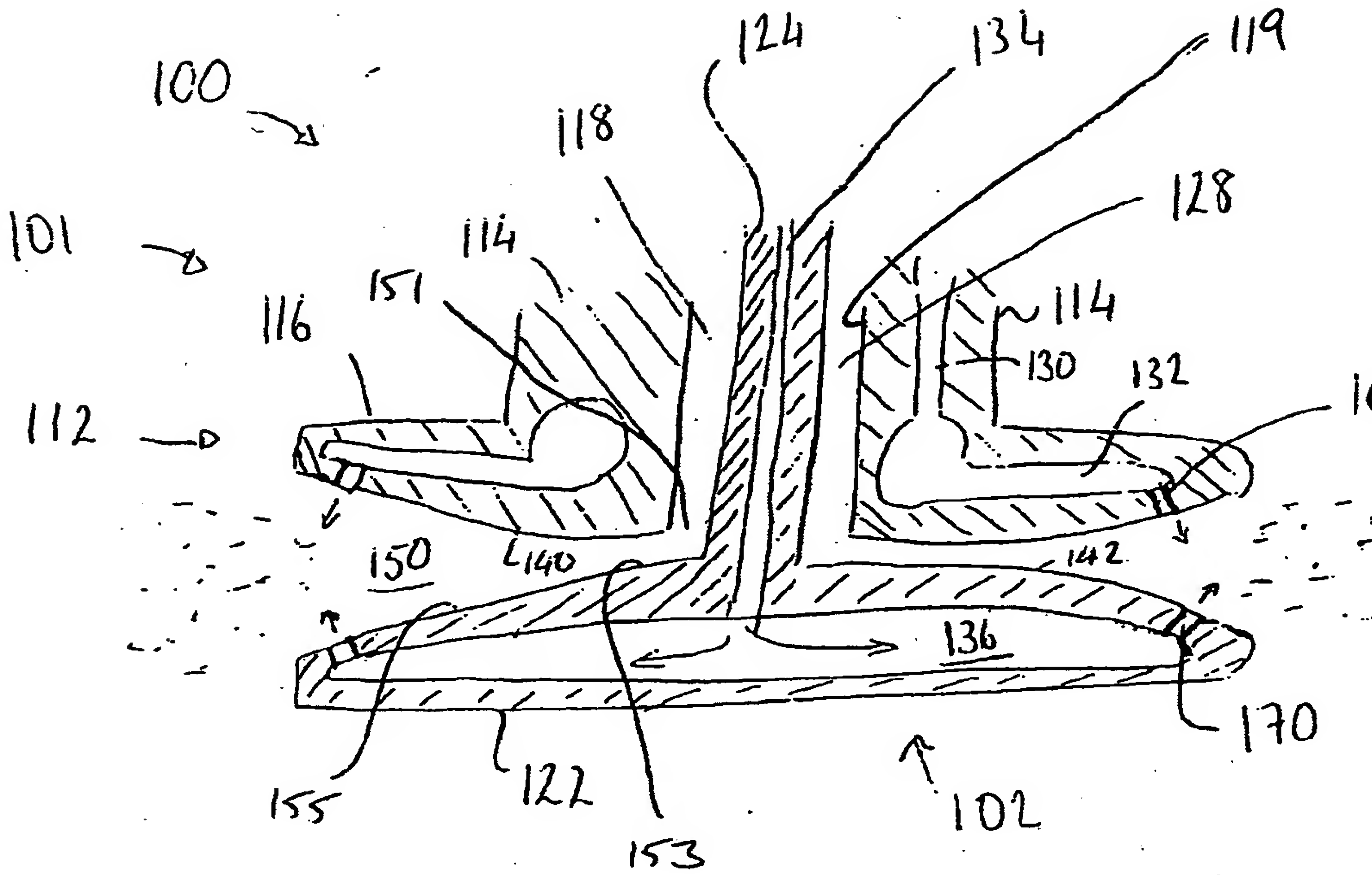
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Fig. 1

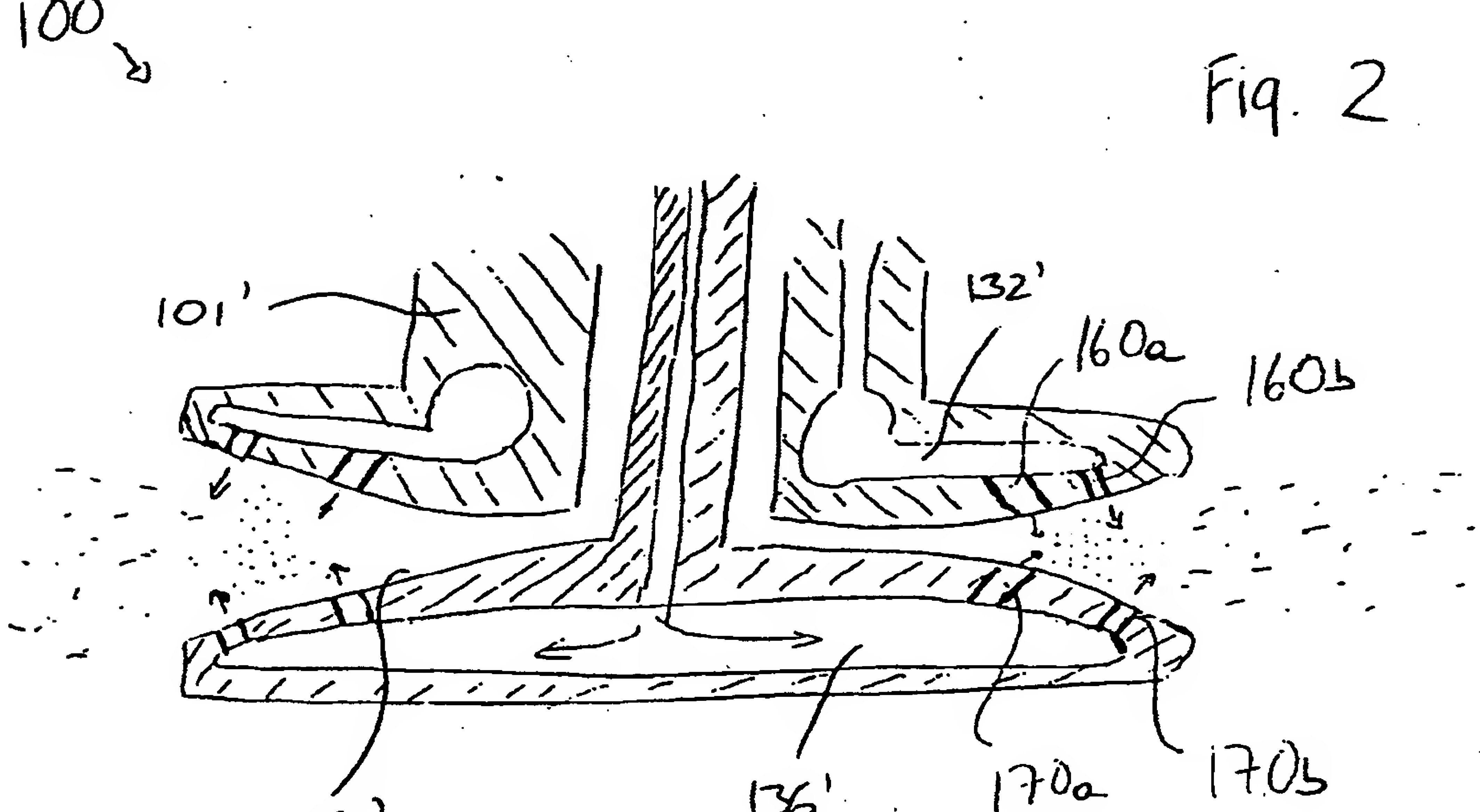
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Fig. 2

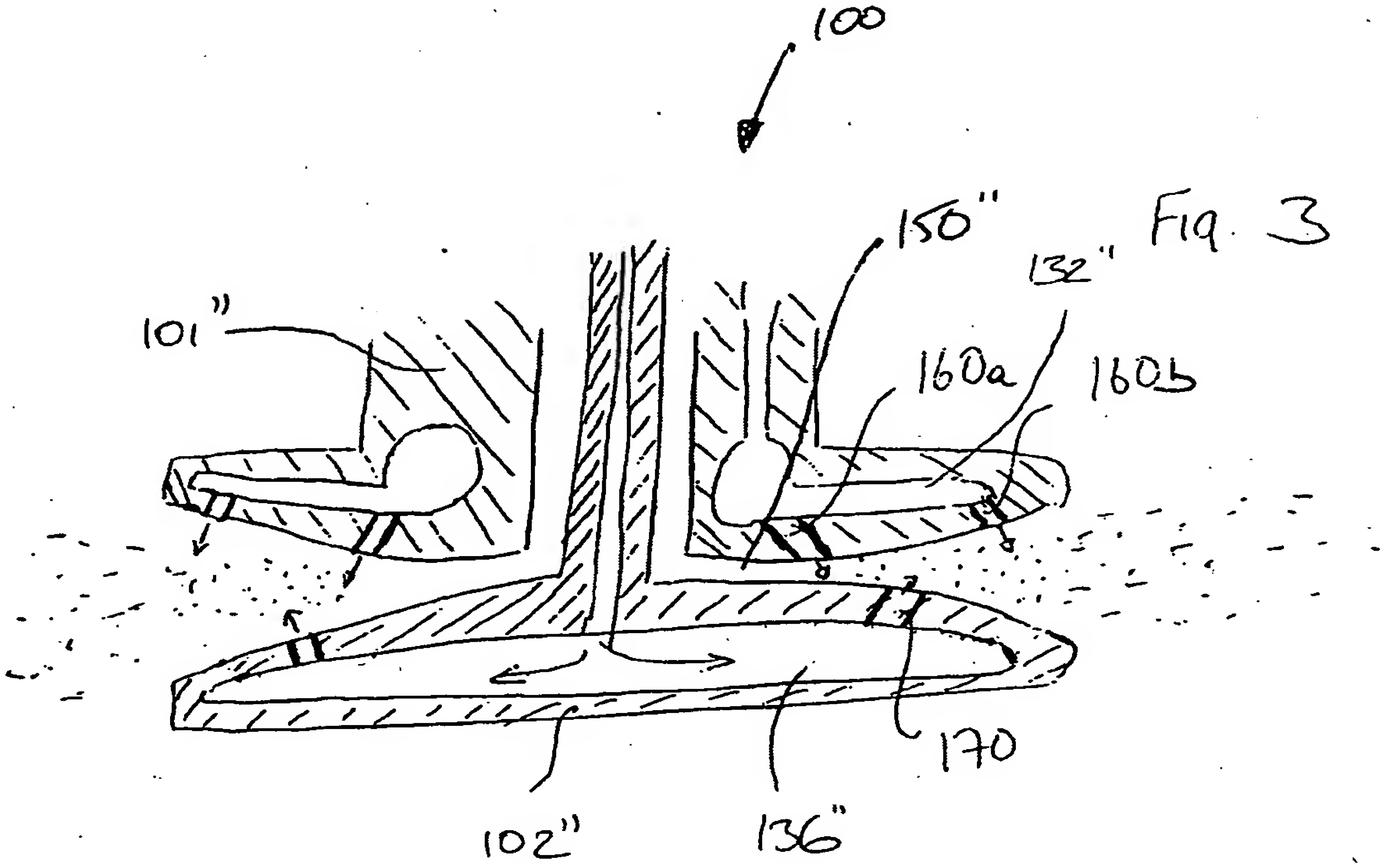

Fig. 3